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BELLCOMM, INC.  
QUARTERLY PROGRESS REPORT  
January February March  
1968

I. M. Ross  
President

BELLCOMM, INC.  
Washington, D. C.

Report No. 68-101-2  
Contract NASW-417

## QUARTERLY PROGRESS REPORT

### ABSTRACT

The activities of Bellcomm, Inc., during the quarter ending March 31, 1968 are summarized. Reference is made to reports and memoranda issued during this period covering particular technical studies.

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## APOLLO/SATURN SYSTEMS ENGINEERING STUDIES MISSION PLANNING

### Mission Assignment

The draft of the Apollo Flight Mission Assignments document prepared during the previous quarter was approved and subsequently published by NASA.

An updated draft of Apollo Flight Mission Assignments was prepared to reflect program changes which occurred during the first quarter of 1968. This draft was coordinated with the Centers.

Reviews and assessments performed during the quarter included the results of the Apollo 5 mission, the Mission Rules for Apollo 6, and the Prelaunch Mission Operations Report for Apollo 6. The results of a study of earth/moon impact possibilities for the Apollo 6 S-IVB stage were presented to the Apollo Program Office.

### Earth Launch Studies

Studies were continued on the launch window for the lunar mission.<sup>(1,2)</sup> A presentation was made to personnel in the Apollo Program Office on some effects of decreasing the launch window duration for Apollo lunar missions.

### Trajectory Analysis

Assessment continued of multiple burn techniques as a means of reducing propellant costs of deboost into lunar parking orbit.<sup>(3,4)</sup> Emphasis has been

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- (1) This was subsequently reported in Analytical Evaluation of Launch Strategy Using Past Countdown Hold Data, TM-68-2014-3, W. B. Gevarter, April 11, 1968.
  - (2) Countdown Hold Statistics, TM-68-2014-1, W. B. Gevarter, January 8, 1968.
  - (3) Semi-Analytic Solution to an Optimum, Two-Impulse Targeting Problem, TM-68-2011-1, S. L. Levie, Jr., March 7, 1968.
  - (4) Analytical Solution to an Optimum Two Burn Deboost Into Parking Orbit, Memorandum for File, S. F. Caldwell, February 14, 1968.

on two-burn maneuvers which retain the free return mission mode. Under this flight plan, the first burn brakes the vehicle into lunar orbit with some plane change, and the second maneuver completes the required plane change.

Lunar Orbiter tracking data is being analyzed to develop an optimum expression of lunar gravitational fields for close prediction of satellite orbits. A study has been made comparing the currently available gravitational potential models. Several trajectories have been generated to compare the effects of these models.

A compendium of the moon's motion and geometry for the period 1966 through 1985 was completed and published. (5) This report provides tabular and graphical presentations of a number of parameters associated with the geometry and dynamics of the Earth-Moon-Sun system. Presentation of the data in this form makes possible a rapid scanning and approximate determination of those parameters satisfying a given set of mission requirements.

A study was begun to determine the availability of lunar landing sites for the period from July 1970 through December 1973.

#### Vehicle Performance

Monthly preparation and delivery of Weight and Performance Reports continued.

#### Guidance Analysis

A short study was undertaken to explore the potential for major software simplification in the spacecraft guidance computers. (6) It was concluded that it would probably be technically feasible to accomplish the lunar landing mission with a program which would require about half the present memory capability of the computers. It would require, however, some simplification of the functions and general relaxation of requirements. More extensive use would have to be made of ground computing facilities and the up-data links, and more

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(5) A Compendium of the Moon's Motion and Geometry: 1966 through 1985, TR-68-310-1, J. O. Cappellari, Jr., January 9, 1968.

(6) Feasibility Study for Simplified Apollo Guidance, Memorandum for File, R. V. Sperry, March 29, 1968.

crew participation was assumed. Supporting memoranda covering individual phases of the study were issued. (7-13)

A recommendation was presented to the Apollo Program Director for deletion of the requirement to provide spacecraft backup for guidance during translunar injection. The requirement was subsequently deleted.

A hybrid simulator is being constructed under subcontract to Electronics Associates, Inc. for use in studies of the Entry Monitor System (EMS). Acceptance tests of the simulator are planned during the next quarter and verification testing of the EMS will start after acceptance of the simulator.

A Bell Telephone Laboratories study on the reduction of look angle sensitivity to altitude update was furnished to MSC where the concept is being explored for possible incorporation in the LM computer. (14)

A study is in process to evaluate the effect of sloping terrain on LM descent.

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- (7) Simplified Software for the Apollo Guidance Computer-CSM Powered Flight Programs, Memorandum for File, D. A. Corey, March 11, 1968.
  - (8) An Open Loop Crew-Monitored LM Descent, Memorandum for File, F. Heap, March 26, 1968.
  - (9) Feasibility of a Simplified LM Ascent and Rendezvous Scheme, Memorandum for File, D. R. Anselmo, D. J. Toms, March 26, 1968.
  - (10) LM Descent Guidance for a Feasibility Study to Simplify Apollo Guidance, Memorandum for File, G. L. Bush, March 27, 1968.
  - (11) A LM Rescue Strategy Requiring No On-Board Targeting, Memorandum for File, S. L. Levie, Jr., March 28, 1968.
  - (12) Proposed Simplification of the CSM-Digital Autopilots, Memorandum for File, A. Heiber, F. LaPiana, March 27, 1968.
  - (13) AGC Reprogramming Study - Utility and Service Programs, Memorandum for File, J. J. Rocchio, March 29, 1968.
  - (14) Reduction of Look Angle Sensitivity to Altitude Updates During LM Descent Visibility Phase, Memorandum for File, G. N. Klemuschin, R. W. Srch, Bell Telephone Laboratories, November 13, 1967.

A study concluded that nominal targeting for the earth entry of the CM for the Apollo 6 (AS-502) mission was satisfactory for nominal conditions but that misses could be caused by low lift-to-drag ratio or velocity. (15)

#### Flight Software Analysis

Bellcomm participation continued in the Apollo Guidance Software Task Force which was formed in December 1967 to review software development and verification procedures. Minutes were issued for the meetings which were held during the quarter, and responses were generated to four action items of the Task Force.

#### Lunar Roving and Flying Vehicles

Lunar flying unit trajectory and sortie analyses were developed for multi-stop impulsive, constant altitude—constant velocity, and semi-ballistic trajectories. (16) The effect of velocity, altitude, number of stops, and payload on the range of a representative flying unit was evaluated.

Two methods were examined for reducing the landed weight of a lunar roving vehicle by using a battery from a modified LM. (17) Roving vehicle range and the effect of a single battery failure were considered.

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(15) AS-502 Entry Accuracy, TM-68-2014-2, I. Bogner, S. B. Watson, March 28, 1968.

(16) Lunar Flying Unit Trajectory and Sortie Analysis, TM-68-1022-2, J. W. Powers, March 15, 1968.

(17) Use of a Battery from the Extended LM to Power a Lunar Roving Vehicle, Memorandum for File, J. Gillespie, January 25, 1968.

## APOLLO/SATURN SYSTEMS ENGINEERING PERFORMANCE AND DESIGN REQUIREMENTS

### Apollo Program Specification

Evaluation of MSC change requests and recommendations in the MSC document, Apollo Spacecraft Weight and Mission Performance Definition, dated December 12, 1967, resulted in a proposal for revisions to certain  $\Delta V$  allocations, Isp requirements, tank capacities, and spacecraft control weights. The revisions were subsequently approved and issued.

### Communication Studies

The analysis of the backup rendezvous ranging system which uses the VHF communication link between the CSM and the LM was continued. In this mode, the VHF voice communication link is modified to permit the LM to transmit back to CSM the tones received from the CSM. An analysis of the operation of the fine tone tracking loop in the LM was completed. (18)

Analysis of the Apollo Unified S-Band System performance continued. A computer program is being devised to determine the performance of the space vehicle and MSFN receivers using signal-to-noise ratio as the measure of performance.

### Launch Systems

A report was prepared covering the configuration, operation and present status of the Apollo Abort Advisory System (AAS) for the Apollo 6 (AS-502) mission. (19) A presentation was made to the Apollo Program Office summarizing the differences in the planned operation of the AAS for Apollo 6 and for a manned mission.

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(18) Analysis of the Operation of the Fine Tone Tracking Loop of the LM VHF Ranging Transponder, TM 68-2034-2, K. H. Schmid, February 1, 1968.

(19) Status of Apollo Abort Advisory System (AAS) for AS-502, Memorandum for File, C. H. Eley, III, February 1, 1968.

Study was continued on the characteristics and use of bromotrifluoromethane (Halon 1301). Reports were prepared on aspects of Halon toxicity and its performance in situations involving hypergolic propellant spills. (20, 21)

A method was described for accomplishing a command module cabin leak check prior to introduction of the lift-off atmosphere by procedures which would allow use of a 5 psi differential pressure, but a flammability risk below that accepted for the flight atmosphere. (22)

A method was described for control of CM fuel cell reaction pressures in Apollo 6 during the period from Mobile Support Structure (MSS) removal to launch through adjustment of the proportion of electric power requirements that are supplied by fuel cell and Ground Support Equipment (GSE) sources. (23)

A study of the LM Supercritical Helium (SHe) System found that it imposed time constraints on countdown recycle, and mission operations which could be alleviated by moderate uprating of the system. (24) An oral summary of the study was presented to the Apollo Program Office.

An oral summary which highlighted critical operations and constraints during a recycle from a scrub on a lunar mission was presented to the Apollo Program Office.

A graphic description of recycle and countdown vs T-time of scrub was prepared for inclusion in the Apollo 6 Mission Operations Report.

A briefing on Apollo egress procedures was presented to Air Force MOL Operations and Safety personnel.

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(20) Halon 1301 Toxicity: A Status Report, Memorandum for File, L. G. Miller, February 7, 1968.

(21) Recent Activities Relating to the Use of Halon 1301 at KSC, Memorandum for File, L. G. Miller, February 19, 1968.

(22) On Pad Command Module Leak Check for Block II Spacecraft, Memorandum for File, L. G. Miller, February 6, 1968.

(23) Supercritical Cryogenics Management Between MSS Removal and Launch - Apollo 6, Memorandum for File, G. W. Craft, March 19, 1968.

(24) A Proposal for Uprating the LM Supercritical Helium (SHe) System, Memorandum for File, D. M. Duty, March 29, 1968.

## Launch Vehicles

A review of fracture mechanics laboratory test data for S-II fuel tank materials was carried out in conjunction with an overall study of S-II stage cryogenic proof testing. The review indicated a need for additional fracture mechanics data in several areas significant to the Apollo Program. (25)

It was also shown that the cryogenic proof test now planned for manned stages will envelope flight loads only up to about 60% of the design wind loads. Further study of Saturn V design wind loads is needed to verify a tentative conclusion that proof test levels need not be changed. (26)

## Spacecraft

The significant results of the materials selection and spacecraft flammability test program developed for the Apollo Program were summarized for the Associate Administrator and a draft report was submitted to NASA. (27)

Studies of spacecraft cabin atmospheres for use on the launch pad were summarized for the Apollo Program Director. It was noted that the use of air for prelaunch pressurization would significantly reduce the flammability hazard. However, use of air would require flight crew participation for the transition to an oxygen flight atmosphere and there would be a period of several minutes during the mission when the cabin atmosphere is non-viable. From the standpoint of physiological factors, a 70% concentration of oxygen would provide sea level equivalent performance with margin to allow for worst case spacecraft hardware operation. A 60% oxygen - 40% nitrogen atmosphere, as proposed by MSC, would provide a viable cabin and would not add significant crew procedures for the atmosphere exchange operation. This composition would provide a reduction in flammability with a slightly reduced margin for physiological factors. (28)

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(25) Analysis of S-II Fracture Mechanics Data, Memorandum for File, R. E. Hunter, March 22, 1968.

(26) The Relation of In-flight Loads to the S-II Cryogenic Proof Test, Memorandum for File, R. E. Hunter, February 9, 1968.

(27) Contributions of the Apollo Materials Selection and Test Program to Future Manned Systems, Memorandum for File, S. S. Fineblum, February 6, 1968.

(28) CM Cabin Atmosphere Briefing, Memorandum for File, T. L. Powers, March 5, 1968.

A study was completed of the physiological adequacy of a 60% oxygen - 40% nitrogen prelaunch Apollo cabin atmosphere for various crew-suit configurations. It was concluded that a 60% oxygen mixture is adequate for suited crewmen with helmets off; however, enrichment to a sea level equivalent atmosphere should be accomplished within a few hours. Enrichment to about 80% oxygen should be achieved prior to suit removal to provide a margin for suit donning in case of cabin pressure failure. (29)

A method for transition from an air prelaunch cabin atmosphere to an oxygen flight atmosphere was proposed. This method requires initial enrichment to a 40% oxygen atmosphere during or following the prelaunch cabin leak check and subsequent venting and repressurization during boost. Three rapid cycles of manned cabin venting to 3.5 psia and automatic repressurization to 4.6 psia are sufficient to achieve a sea level equivalent atmosphere composition at the time of orbital insertion. (30)

A review of the configuration of the Apollo CSM electrical power system was concluded. Changes in the interconnections among energy sources and distribution busses during the course of a manned mission were illustrated. (31)

Effort to assure compatibility of program requirements and equipment capability included continuing participation in design reviews of the CM crew couch and the Environmental Control System (ECS) electronics. A design assessment was made of current configurations of the ECS 2.40 Water/Glycol Temperature Controller.

### Flight Safety

An activity has been started in connection with the Apollo Crew Safety Review Board which was organized to make an independent and comprehensive assessment of Apollo flight crew safety for preflight and flight operations. Suggestions concerning the charter and the activities of the group were provided and a list of possible areas of concern was prepared.

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(29) Crew/Suit Configurations with a 60:40 O<sub>2</sub>: N<sub>2</sub> CM Cabin Atmosphere, Memorandum for File, T.A. Bottomley, Jr., February 26, 1968.

(30) A Semi-automatic Procedure for Controlling CM Cabin Atmosphere Enrichment, Memorandum for File, R.D. Raymond, February 21, 1968.

(31) CSM Electrical Source/Distribution Bus Configurations During Manned Block II Flight, Memorandum for File, W.H. Hodge, March 14, 1968.

Activity continued in conjunction with the MSF Safety Office in the development of a flight safety plan covering studies and program implementation for a five-year period. Draft statements reflecting variations of the plan were prepared and delivered.

Other related efforts included assessment of an orbital escape study, review of a proposed Apollo Safety Plan, and development of requirements for certifying the design of the Launch Complex 39 slidewire and for man-rating the device.

## APOLLO/SATURN SYSTEMS ENGINEERING SCIENTIFIC STUDIES

### CSM Photography

A summary of the current Apollo photographic planning and photographic equipment aboard the CSM and LM was completed. (32) The report also suggested scientific photographic experiments for the CSM in lunar orbit for both the nominal and contingency cases and recommended that the 250 mm lens be returned to the CSM photographic complement.

Work in conjunction with the United States Geological Survey Office, Menlo Park, was done to establish the scientific objectives of CSM photography. Continued Bellcomm participation in this project is anticipated.

### Apollo Lunar Landing

Visibility on the lunar surface was investigated. (33) The maximum range of visibility of several objects of geological interest was determined as a function of height-of-eye, sun angle, azimuth, and slope. It was shown that increasing the astronaut's height-of-eye, e. g. , from the lunar surface to the LM ascent stage, significantly increases the detection range of rimless craters. For positive features, such as crater rims and blocks, visibility is determined mainly by the distance to the horizon and is otherwise independent of height-of-eye. In all cases, visibility is greater facing the sun than facing away from the sun. It is concluded that most objects of interest will be visible out to the astronauts' 1 km radius-of-action.

### Apollo Lunar Surface Experiments Package (ALSEP)

Changes in the Central Station thermal design were suggested and agreed upon during ALSEP meetings with MSC and Bendix. (34) The effect of LM ascent plume dust on the ALSEP thermal control is also under investigation.

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(32) Apollo CSM Photographic Planning, Memorandum for File, W. L. Piotrowski, March 29, 1968.

(33) Astronaut Visibility of Features from the Lunar Surface, Memorandum for File, A. F. H. Goetz, January 19, 1968.

(34) ALSEP Central Station Thermal Design, Memorandum for File, P. J. Hickson, February 16, 1968.

A program has been initiated for studying high voltage arcing problems encountered in several ALSEP instruments during the last several months. Possible causes of voltage breakdown in space environments and techniques for eliminating these problems are being studied.

A study is underway on the feasibility of using the ALSEP dust detector for lunar surface temperature measurements.

The rationale for partial deployment of ALSEP on the first EVA period of the first lunar landing mission was investigated. An attempted partial deployment would indicate whether the unloading procedure is correct and verify the working of the Remote Deployment Mechanism (RDM). The result of this would be an input for a second EVA go/no-go decision and would provide confidence in the RDM should the mission abort before the second EVA.

#### Lunar Mission Studies

In conjunction with work on the NASA lunar exploration plan a detailed mission plan for the Apennine Front - Hadley Rille site was prepared and submitted for incorporation in the NASA Plan for Lunar Exploration.

An investigation was undertaken for a geologic exploration on a hypothetical second Apollo landing mission. (35) The study assumed a random landing point within a specified area bounded by the three sigma dispersion ellipse. Based on specific exploration objectives derived from interpretation of Lunar Orbiter photography, two sample geological traverses were developed. The traverses were consonant with the operational constraints of EVA time, astronaut mobility, lighting conditions, and landing location.

A study was conducted of a hypothetical lunar landing mission to a mare ridge. (36) The investigation proposed geological traverses and timelines (within the operational constraints) for a mission that utilized LM redesignation capability for a point landing adjacent to a specific mare ridge. This type of mission assumes more capability to control the touchdown point than that assumed for an early Apollo mission.

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(35) A Proposed Plan for Geologic Exploration on the Second Apollo Landing Mission, Memorandum for File, A. F. H. Goetz, January 31, 1968.

(36) A Lunar Landing Mission to a Mare Ridge, Memorandum for File, M. T. Yates, February 14, 1968.

## Lunar Exploration Planning

A briefing was presented to the Apollo Lunar Exploration Office (MAL) on the history, operation and current status of the Apollo site selection process.

Material was submitted informally to NASA dealing with the alternate ways of obtaining additional lunar orbital measurements to be used for site survey for lunar missions beyond the early Apollo missions. It was observed that:

1. The use of Lunar Orbiter VI to increase and improve our immediate catalog of lunar data would be desirable.
2. The use of a new block of Lunar Orbiters unchanged from Block I and flown on the fastest possible schedule would be undesirable.
3. The development of a Block III Lunar Orbiter to be flown later in the program is desirable. Improvements in the geometric fidelity of the readout system or the use of a film return system is desirable. If the former can be achieved, then the weight saved can be used for remote-sensing or photography other than site survey.
4. The development of a camera and a set of photographic and remote-sensing experiments for use in a manned orbital mission is a back-up position to the development of a Lunar Orbiter Block III.

An evolving lunar exploration strategy was further developed at meetings of the Group for Lunar Exploration Planning on January 11 and February 26. A presentation entitled "A Set of Mission Assignments for the Lunar Exploration Plan" was given to the Lunar and Planetary Missions Board (Flagstaff, March 14) and to the Apollo Site Selection Board (Washington, March 26). Recommendations for the first eleven lunar missions included mission objectives, sites, staytimes, configurations and mission profiles. Extravehicular activities were outlined for about half of the missions and the expected scientific accomplishments were summarized.

## APOLLO APPLICATIONS SYSTEMS ENGINEERING MISSION PLANNING

### Weight Reporting

The "Monthly Weight and Performance Summary" document was prepared and issued during January and February, 1968. The quarterly "AAP Weight and Performance Report" dated March 15, 1968 was prepared, approved by the AAP Program Director, and issued.

### Mission Analysis

Unmanned rendezvous and docking of the AAP-4 LM/ATM to the cluster has been suggested by MSC as a means of alleviating the operational complexity of the AAP-3/AAP-4 dual rendezvous. A presentation was given to the AAP Program Director which detailed the feasibility of performing such a rendezvous and described methods by which this may be accomplished. (37)

A phasing scheme suitable for rendezvous of an unmanned chase vehicle with a manned target vehicle was proposed. (38) This scheme can easily correct relatively large downrange insertion errors by taking advantage of the fact that in the rendezvous of an unmanned chase vehicle with a manned target vehicle it is desirable to initiate the terminal phase from above the target.

Several changes have been made in the Bellcomm Apollo Simulation Program (BCMASP) for Saturn IB earth orbital missions. (39) The most significant modification was the adjustment of the first-stage thrust model so that the BCMASP calculated payloads agree closely with MSFC payload calculations for AAP missions. Other changes to the program include the incorporation of an option to simulate Spacecraft Lunar Module Adapter (SLA)/Nose Cone jettison during powered flight.

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(37) LM/ATM Unmanned Rendezvous and Docking, Memorandum for File, K. E. Martersteck, February 15, 1968.

(38) Possible Approach to Phasing for Unmanned Rendezvous, Memorandum for File, K. E. Martersteck, February 29, 1968.

(39) Modification to the BCMASP Simulator for Saturn IB Trajectories, Memorandum for File, I. Hirsch, March 29, 1968.

The review of Gemini Flight planning, which has been underway for sometime at the request of MSC, was completed. The purpose of this review was to analyze the flight planning process, define the basic functions of flight plans, and define mission variables which affect flight planning. (40) Flight plans for Gemini missions were studied which illustrate many factors associated with rendezvous, experimentation, EVA activity, and other earth-orbital operations that are expected to be encountered on AAP missions. The results were presented in the form of flight planning constraints and illustrated how mission variables affect an allowable sequence of operations.

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(40) Flight Planning Study - Review of Gemini Flight Plans, Memorandum for File, B. H. Crane, March 1, 1968.

## APOLLO APPLICATIONS SYSTEMS ENGINEERING PERFORMANCE AND DESIGN REQUIREMENTS

### Baseline Configuration

Major configuration problems were identified and Center participation was coordinated for the Apollo Applications Program (AAP) Baseline Review held on February 27 and 28. Minutes for this meeting and a list of action items were prepared, approved by the Program Director, and distributed.

An analysis was made of the conditions which must be verified on AAP-2 in earth orbit prior to the start of the terminal countdown of AAP-1.<sup>(41)</sup> It was concluded that the AAP-2 space vehicle status can be verified in sufficient time to permit updating of guidance tapes, terminal countdown and launch of the AAP-1 space vehicle within 24 hours of the AAP-2 launch.

An examination was made of the current AAP-1/AAP-2 mission timeline. A description was prepared of the daily activities of the crew and the major cluster events which must occur during the course of the mission.<sup>(42)</sup>

A description and assessment of the Orbital Workshop's (OWS) Environmental Control System (ECS) was prepared at the request of the Program Director.<sup>(43)</sup> It was concluded that an increase in the degree of active thermal control of the environment is desirable for off-nominal attitude orientations of the cluster. MSFC is currently considering methods to decrease the sensitivity of the OWS to the external thermal environment. Although both condensation over large areas or the development of fog conditions are unlikely to occur, it was found that the present ECS was not capable of preventing local condensation of atmospheric water vapor.

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(41) AAP-2 Conditions Prior to Launch of AAP-1, Memorandum for File, A. W. Starkey, March 21, 1968.

(42) AAP-1/AAP-2 Simplified Mission Description, Memorandum for File, D. S. Lopez, March 11, 1968.

(43) Orbital Workshop Environmental Control System, Memorandum for File, D. J. Belz, March 11, 1968.

A report on the status of the OWS thermal analyses by McDonnell - Douglas (MCASTRO) and MSFC was presented at the AAP Review in January. MSFC and MCASTRO are in substantial agreement regarding Workshop orbital transient temperature predictions and inertial orientation temperature predictions. (44) Thermal analysis is continuing for the perpendicular-to-the orbital-plane (POP) flight attitude.

The Lunar Module/Multiple Docking Adapter (LM/MDA) bending moment during CSM axial docking was examined as a function of interface stiffness. (45) It was concluded that the bending moment at the LM/MDA interface could be lowered by reducing the required interface stiffness. This would effect a savings in MDA weight of approximately 400 pounds.

A review was performed of the AAP 3-4 electrical energy sources and load requirements. (46) The results indicated that the baseline electrical power system is adequate for the presently known and projected electrical loads.

An evaluation was made of decoupling the Command and Service Module/Lunar Module/Apollo Telescope Mount (CSM/LM/ATM) from the OWS. (47) It was concluded that such a mission simplifies operational requirements and, if used as the prime mission mode, provides substantial weight advantages. The major disadvantage is that it reduces the development and demonstration of orbital assembly techniques on early AAP missions.

Additional work was performed in defining AAP cluster cabin atmospheric contamination sources, in surveying available atmospheric contamination control system devices, and in reporting representative contaminant control standards employed by the military and industry. (48)

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(44) Status of McDonnell-Douglas Thermal Analyses of the Orbital Workshop, Memorandum for File, D.J. Belz, February 5, 1968.

(45) This was subsequently reported in Structural Loads Induced by AAP Spacecraft Docking Dynamics, Memorandum for File, W. W. Hough, April 1, 1968.

(46) AAP 3-4 Electrical Energy Sources and Load Requirements, Memorandum for File, B. W. Moss, March 4, 1968.

(47) Coupled vs. Decoupled LM/ATM Mission Concepts: System Configuration Aspects, Memorandum for File, R. K. McFarland, February 14, 1968.

(48) Control of Cabin Atmospheric Contamination in the AAP Cluster, Memorandum for File, D.J. Beltz, February 28, 1968.

### Attitude Control Studies

A study was completed on the stability of an uncontrolled OWS in a local vertical attitude during storage. (49) It was found that aerodynamic torque is a destabilizing disturbance and that a spacecraft of the OWS class has an unstable equilibrium point with respect to local vertical. The orientation of the solar panels on the OWS influences the degree of instability. By turning the panels at right angles to the OWS roll axis, the instability is minimized. Simulations of the unstable attitude oscillations have shown that they grow at a low rate and that only infrequent reinitialization to a local vertical attitude will be required.

Studies of the ATM Pointing Control System indicated that a system of this type could hold the pointing attitude of a telescope to within  $\pm 0.1$  arc sec (peak) in the presence of gravitational, aerodynamic, and crew motion disturbances. (50) Such performance could be achieved on a vehicle the size of the OWS provided that sensors are sufficiently free of nonlinearities and that the experiment package itself is sufficiently stiff. Thermal distortion, which may be a limiting factor, was not studied as part of this analysis.

### Communications Studies

A review of proposed intercenter Interface Control Documents for AAP Instrumentation and Communications (I&C) systems was conducted. Comments on this documentation were prepared and distributed to the I&C Panel. (51)

The proposed ATM I&C system which was presented at the ATM Preliminary Requirements Review was evaluated. (52) It was concluded that the following areas merit further attention: ATM Caution and Warning System, ATM equipment voltage breakdown, ATM I&C operational mode displays, ATM

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- (49) Passive Stability of the Local Vertical (Gravity-Gradient) Orientation of the Orbital Workshop (OWS), TM-68-1022-1, J. Kranton, January 5, 1968.
- (50) The Pointing Accuracy Attainable with Orbiting Gimbal-Mounted Telescopes, Memorandum for File, P. G. Smith, February 2, 1968.
- (51) Review of AAP I/C Panel Instrumentation and Communications Interface Control Documents, Memorandum for File, A. G. Weygand, February 15, 1968.
- (52) Comments on the Instrumentation and Communication System of the ATM as Proposed by MSFC at the ATM PRR, Memorandum for File, A. G. Weygand, January 25, 1968.

command requirements, LM/ATM telemetry interfaces, electromagnetic compatibility of the ATM and the cluster, and data and operational timing correlation requirements for the modules of the cluster.

#### Experiment Data

The document, "AAP Experiments Data Flow Plan" was submitted to the AAP Program Director and subsequently approved and issued to the Centers for use as a guide for preparation of more detailed documentation. This plan endorses the philosophy that the Principal Investigator will receive data in relatively "raw" form and will be responsible for its reduction.

APOLLO APPLICATIONS SYSTEMS ENGINEERING  
SCIENTIFIC STUDIES

Experiment Evaluation

The applicability of the Boyd-Boksenberg Image Storage System, and electro-mechanical one-dimensional image read-out device, for use with the solar ATM telescopes was investigated. (53) In principle the device is suitable for use with two ATM experiments. However, it was felt that while the device has substantial merit, it has not been sufficiently developed to warrant use on the initial ATM mission.

An analysis of the compatibility of Experiment S051, Sodium Cloud Photography, with early AAP missions has shown that, from the nominal altitude of 230 nautical miles of the AAP cluster, the region of interest in the sodium cloud cannot be photographed with the spatial resolution desired. (54) Therefore, it was recommended that Experiment S051 not be assigned to AAP cluster missions but rather be considered only for missions to be flown at moderately low altitudes.

The Experiment Implementation Plan (EIP) for Experiment M479, Zero Gravity Flammability, was reviewed and several experiment operations were identified as requiring additional definition and analysis. (55)

The EIP for Experiment M489, Wicking Evaporative Heat Sinks, was reviewed and it was concluded that additional analytical work is required before an adequate definition of experiment hardware can be developed. (56)

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(53) The Boyd-Boksenberg Image Storage System, Memorandum for File, T. C. Tweedie, Jr., January 22, 1968.

(54) Compatibility of Experiment S051, Sodium Cloud Photography, with Early AAP Missions, Memorandum for File, T. C. Tweedie, Jr., March 21, 1968.

(55) Comments on Experiment Implementation Plan for Experiment M479, Zero Gravity Flammability, Memorandum for File, M. S. Feldman, January 3, 1968.

(56) Comments on Experiment Implementation Plan for Experiment M489, Wicking Evaporative Heat Sinks, Memorandum for File, M. S. Feldman, January 9, 1968.

A critical review was conducted of Experiment T-013. (57) The objective of this experiment is to obtain data for the refinement of a mathematical model of crew motion in a zero-g environment in order that spacecraft responses to crew motions can be determined. This review concluded that by using ground simulations supplemented by spacecraft response analysis the need for T-013 in support of the ATM can be eliminated and considerable simplification of T-013 can be effected for other possible purposes.

The medical experiments approved for the 56-day AAP 3/4 cluster mission were analyzed with respect to the inflight astronaut time required for their execution. (58) It was shown that astronaut time could be saved by combining separate experiments to eliminate task duplications and converting some experiments from two to one-man operation. The total time originally required for medical experiments could then be reduced by as much as 70%.

A brief study was carried out to determine the photographic coverage which the unmanned AS-502 flight provided for orbits over U.S. ground-truth test sites associated with the earth-sensing program. (59) Seventeen sites were covered, ten of which have previously been studied with the MSC aircraft program. Such color photography, using a Maurer 70mm camera, can be particularly useful for calibration and analysis for future earth resources studies.

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(57) Review of Experiment T-013, Crew/Vehicle Disturbance, Memorandum for File, J. Kranton, C. A. Pearse, S. L. Penn, January 16, 1968.

(58) Examination of the Efficiencies Possible in the AAP Medical Experiment Program, TM-68-1011-1, R. E. McGaughy, February 23, 1968.

(59) Earth Resources Aircraft Program Test Site Coverage by Expected AS-502 Color Photography, Memorandum for File, B. E. Sabels, February 19, 1968.

## ADVANCED MANNED MISSIONS SYSTEMS ENGINEERING PROGRAM REQUIREMENTS

### Lunar

All lunar work previously covered in this section has been transferred to APOLLO/SATURN SYSTEMS ENGINEERING.

### Earth Orbit

A draft NASA report of the results of the "Saturn V Launched Orbital Workshops," a study carried out by an OMSF planning group, was prepared. Participation in the study was conducted through membership on (a) the planning group, (b) the task teams assigned to cover Experiment Payloads, Mission Analysis, Configurations, Resupply and Logistics, Schedules and Decision Milestones, and Resources, and (c) the sub-committee on Program Criteria.

Presentations of three invited papers were made to the OART-OSSA meteoroid environment workshop group (March 19-20). The first was a survey of important new information derived from radar meteoroid investigations. The second dealt with the meteoroid environment as obtained from an analysis of photographic meteors. The third paper described a collisional model of asteroids and their debris as a result of dynamical interaction. This last paper was also presented in a seminar at the Ames Research Center in February.

Radiation doses produced by energetic particles trapped in the earth's magnetic field were evaluated for low altitude missions.<sup>(60)</sup> The dependence of dose rate on shielding, altitude and inclination was determined in order to permit tradeoffs among these variables.

The required weights of shielding materials other than aluminum were also calculated.<sup>(61)</sup> It was shown that for large spacecraft, light materials are most efficient, while for smaller shielded volumes, iron becomes more efficient.

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(60) Trapped Radiation Doses, Memorandum for File, R.H. Hilberg, March 15, 1968.

(61) Relative Effectiveness of Several Materials as Radiation Shields, Memorandum for File, R.H. Hilberg, March 29, 1968.

In planning earth orbital missions for astronomy, an important limitation is the occultation of portions of the sky by the nearby earth. An analysis was carried out to determine the properties of this occultation as a function of orbital altitude, orbital inclination, and viewing direction.<sup>(62)</sup> It is shown that along directions close to the orbital poles (perpendicular to the plane of the orbit) one can take advantage of the "unocculted circles" where the earth never interferes with viewing. As the orbit precesses due to the oblateness of the earth, these unocculted circles sweep out swaths of constant declination completely around the celestial sphere in a few months. Low earth orbits (450 km) of intermediate inclination yield continuous viewing times of celestial objects within these circles of about 11 days. By designing the observing program to take advantage of these unocculted zones, one of the major limitations of near-earth orbit astronomy can be overcome.

#### Planetary

Analysis of results from recent mission to Venus was continued in order to arrive at a clearer definition of both the engineering constraints on planetary missions and the experimental program for such missions.<sup>(63)</sup>

Measurements were made of crater diameters on the Aeronautical Chart and Information Center (A.C.I.C.) cartographic reduction of Frames 3-14 of the Mariner IV photographs of Mars.<sup>(64)</sup> The incremental frequency distribution of diameters of craters larger than 20-30 km follows an inverse square law with a crater density equal to that of craters on the lunar continents. This is in accord with the prediction that lunar continents and the Martian surface carry an "equilibrium" density of craters of meteoroidal impact origin. Details of fluctuations in crater counts support this conclusion.

A study was begun in coordination with the Langley Research Center on the question of Mars photometry. The prime objective is to define those aspects of the environment which are necessary for the camera design and

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(62) Effect of Earth Occultation on Astronomical Observations from Earth Orbit, Memorandum for File, D.B. Wood, February 15, 1968.

(63) Review of the Second Arizona Conference on Planetary Atmospheres, Tucson, Arizona, March 11-13, 1968, Memorandum for File, M. Liwshitz, March 28, 1968.

(64) Number Density of Martian Craters, TR-68-710-1, A.H. Marcus, January 29, 1968.

mission planning of a Mars orbital imagery experiment. Data under review consists of earth-based photos and Mariner IV TV imagery.

The validity of using a modified solar wind proton Larmor radius as a criterion for a gas-dynamic description of the solar wind planetary body interaction was examined.<sup>(65)</sup> The conditions under which the gas-dynamic description is justified for interactions with various planetary bodies were defined. A discussion of the effects of a planetary magnetic field or intrinsic electrical conductivity on this interaction was presented.

Work continued on the definition of experiment objectives and payloads for a manned reconnaissance mission to Mars and Venus. A summary report discussed a possible experiment program for a multiplanet (Venus-Mars-Venus) flyby mission in the late 1970's.<sup>(66)</sup> A complement of unmanned probes was described which would be launched from the manned vehicle during the planet approach phase to deliver experiment packages to particular regions of the planetary environment. Several experiments in space physics and astronomy were identified as being particularly suited to the en route portion of the mission since they take advantage of the location of the manned spacecraft during its orbit about the sun.

Three en route experiments that would be particularly valuable during a Mars or Venus manned flyby mission were described.<sup>(67)</sup> An improvement in accuracy of Shapiro's proposed test of general relativity can be achieved by reflecting a radar beam passing close to the sun from an active transponder on board the spacecraft, instead of from a planet such as Venus. Photography of the zodiacal light from a manned spacecraft as it leaves the vicinity of the earth and enters deep space could shed valuable light on the distribution and origin of the scattering particles causing the zodiacal light. Mars flyby missions equipped with a one-meter telescope would provide a rare opportunity to observe

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(65) On the Interaction of the Solar Wind with Planetary Bodies, TM-68-1014-2, J.L. Blank, March 7, 1968.

(66) Experiment Payloads for Manned Encounter Missions to Mars and Venus, TR-68-710-2, W.B. Thompson, J.E. Volonte, G.A. Briggs, P.L. Chandeysson, M. Cutler, E.M. Grenning, W.D. Grobman, R.N. Kostoff, February 21, 1968. (Also published in Proceedings of the Fifth Space Congress, Vol. 2, 1968.)

(67) Three Experiments for the En Route Phase of a Planetary Flyby Mission, Memorandum for File, W.D. Grobman, February 9, 1968.

many large asteroids with higher precision and at larger phase angles for the reflected sunlight than is possible from earth.

A further study was made of valuable astronomical observations possible in the en route phase of such a flyby mission provided with a one-meter diffraction-limited telescope. (68) Stellar objectives include observations of faint sources and spectra, long observations of variable sources, and observations of targets of opportunity such as comets, novae or supernovae. Solar system observations could include photography of liberation clouds of the earth-moon system, and photography of the earth at ranges of distances from a few thousand miles to over one AU to determine the astronomical appearance of a thoroughly studied body.

One possible extension in the experimental investigation of Mars that goes beyond remote sensing from flyby or orbit is the use of an atmospheric entry probe. As composition is one parameter of considerable interest, a review has been conducted to establish the performance and operating requirements of the various types of mass spectrometers which have demonstrated spacecraft application. (69)

A feasibility study of one of the probes for Venus concluded that a useful experiment payload could be delivered to the planet surface for approximately 1000 lbs gross weight at the time of separation from the manned vehicle. (70) While the nominal lifetime of this probe at the surface would be no more than a few hours, it could transmit a significant amount of data on the environment, including a facsimile panoramic scan, back to the manned vehicle.

Another probe which would be deployed at the time of Venus flyby places a number of weather balloons in the atmosphere. These balloons would be subsequently tracked from an orbiting probe to determine the gross circulation patterns of the Venus atmosphere. As currently envisioned these weather balloons would carry small experimental packages to measure properties of the

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(68) Optical Astronomy on a Manned Planetary Flyby Mission, Memorandum for File, W. D. Grobman, February 8, 1968.

(69) A Survey of Possible Experiments for a Mars Entry Probe: I, Mass Spectrometer, Memorandum for File, C. P. Wang, March 26, 1968.

(70) A Venus Lander Probe for Manned Flyby Missions, TR-68-710-3, P. L. Chandeysson, February 23, 1968. (Also published in Proceedings of the Fifth Space Congress, Vol. 3, 1968.)

Venus atmosphere. Similarities between certain atmospheric properties of the Earth and Venus suggest that one useful instrument might be a sferics detector to determine properties of lightning discharges. (71)

Before any manned planetary missions are attempted, a precursory unmanned program seems desirable to extend our knowledge of Mars and Venus beyond that acquired by Mariners II, IV, and V. A preliminary rationale for planetary program planning in the 1970's has been developed, and one particular program is outlined for illustration. (72) This program has three essential branches: one aimed at Mars and Venus as a precursor to manned flight; a second aimed at comets and asteroids to capitalize on Mariner technology; and a third aimed at Jupiter and the outer planets which provide the unmanned program a major scientific and engineering challenge in the 1970's.

An appraisal of various alternatives to the Voyager program in the period 1968-1975 led to identification of two general categories of alternatives. The first covers an interim spacecraft design based on existing spacecraft with commitment to a Voyager-type design postponed until the mid-70's. (73) The second involves an early commitment to a Voyager-type design supported by a program of up-rating the spacecraft at each opportunity to grow to full Voyager capability.

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(71) Lightning Discharges and Sferics, Memorandum for File, W.R. Sill, February 23, 1968.

(72) A Feasible Planetary Exploration Program Through 1980, TM-68-1014-1, J.P. Downs, W.B. Thompson, February 26, 1968.

(73) Appraisal of Unmanned Planetary Program Alternatives to Voyager in the Period 1968-1975, Memorandum for File, P.L. Chandeysson, M. Cutler, January 16, 1968.

ADVANCED MANNED MISSIONS SYSTEMS ENGINEERING  
MISSION ANALYSIS

Range safety considerations have, so far, limited the southeasterly launches from the Pacific Missile Range to an azimuth of approximately  $171^{\circ}$ . A brief study was conducted to show which easterly launch azimuths would result in flights over land. (74) An azimuth of  $143.4^{\circ}$  would lie tangent to the westernmost tip of the Baja California peninsula in Mexico. Further down range it would cross the coast of Chile. An azimuth of  $154^{\circ}$  would clear the coast of Chile completely but overfly some islands while an azimuth of  $157^{\circ}$  -  $158.5^{\circ}$  would avoid any land for a down range distance of about 7,500 miles.

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(74) Launch Azimuth from the Pacific Missile Range, Memorandum for File, J. J. Schoch, February 28, 1968.

## ADVANCED MANNED MISSIONS SYSTEMS ENGINEERING CONFIGURATION STUDIES

A conceptual design of a communications and tracking system that is suitable for operation with a Drag Probe on a manned Mars flyby mission was completed.<sup>(75)</sup> The design permits transmission of data from the probe to the mission module as well as providing for periodic or continuous range and range-rate tracking. A method of optimally utilizing the rf transmitter power is outlined. The weight of the equipment required for the system is also discussed.

An evaluation of the performance of diversity communications systems in a multipath environment was started. This study is intended to determine the communication performance in a probe-to-mission module system when the multipath varies.

A study of pressure bulkhead configurations for a cylindrical manned spacecraft of 20 feet diameter was completed.<sup>(76)</sup> Preliminary weight estimates were determined for both ellipsoidal and elliptical-toroidal bulkheads. It was concluded that the elliptical-toroidal bulkhead, with crown heights ranging from 1.5 feet to 3.5 feet, is approximately 24% to 34% lighter than an ellipsoidal bulkhead with the same crown height.

An analysis concluded that it was feasible to incorporate radiators for thermal control in the design of manned planetary spacecraft for the meteoroid/asteroid environments.<sup>(77)</sup> The lowest weight results from modularizing the radiator and permitting puncture (probability of loss of one module = 0.001) as opposed to shielding to prevent puncture. If radiator design is area-limited, simple radiator modularization will permit continued operation, but at reduced power levels in the event of a puncture (probability = 0.001).

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(75) Communication System Design for a Mission Module-Drag Probe Link on a Manned Mars Flyby Mission, TM-68-2034-1, R.K. Chen, February 15, 1968.

(76) Weight Estimates of Ellipsoidal and Elliptical-Toroidal Bulkheads of a Common Mission Module, Memorandum for File, C.E. Johnson, C.C. Ong, January 9, 1968.

(77) Comments on Design Policy for the Use of Radiators in a Meteoroid/Asteroid Environment for Advanced Manned Missions, Memorandum for File, C.E. Johnson, January 10, 1968.

A recent contractor study for the Jet Propulsion Laboratory, Pasadena, presented an optimum antenna selection for unmanned missions. That study investigated six types of foldable antennas which could be erected in space. The study was reviewed and it was concluded that the individual petal technique was superior to the other types for meeting the requirements for manned missions.

A number of radioisotopes were investigated as possible heat sources for space electrical power systems on-board long duration manned missions in the 1970's.<sup>(78)</sup> Pu-238 was found to be the most attractive isotope although it will have somewhat limited availability in the early and middle '70's. Pm-147 was found to be the best alternative to Pu-238. Since isotope production generally exhibits a long delay (3 to 7 years) between a rise in demand and a rise in supply, long-range mission planning is essential. Current trends in isotopic power generation systems for space application are discussed. Nuclear safety appears achievable even for the large (25 kilowatt, thermal) systems now under development although there is some weight penalty.

A conceptual design of interface elements that would be used between the modules of a triply modular redundant (TMR) computer was completed.<sup>(79)</sup> The different modes of the interface elements would allow a TMR spaceborne computer to be used at various times in a mission as one triplicated machine, one duplex plus one simplex machine, or three simplex machines.

A study was performed to determine CSM configuration requirements for supporting Saturn V Orbital Workshop Missions.<sup>(80)</sup> Performance margins were determined for the configurations as a function of orbit altitude and inclination. Maximum payload capabilities for both the ascent and the earth return phases were also determined. In conjunction with this study, a review was performed to identify the subsystem modifications made to the Gemini spacecraft for quiescent spacecraft orbital operation in support of the MOL

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(78) Radioisotope Heat Sources for Space Power Application, Memorandum for File, C.P. Witze, March 15, 1968.

(79) Triplicated Interface Element for Triply Redundant Modules in Digital Devices, Memorandum for File, D.O. Baechler, February 5, 1968.

(80) CSM Configurations to Support Saturn V Workshops, Memorandum for File, J.J. Gabrik, W.W. Hough, March 5, 1968.

program. (81) Gemini modifications were examined to determine their applicability to quiescent CSM concepts.

A review of water reclamation technology which is applicable to manned spacecraft missions was performed. (82) The most promising of the many water recovery techniques were described, and the advantages and disadvantages of each were outlined.

A review of MSFC's preliminary thermal analyses for the Saturn V Orbital Workshop was prepared. (83) It was concluded that utilization of the Saturn I Orbital Workshop thermal control system concept is not feasible for Saturn V applications when the Workshop is aligned with its minimum projected area exposed to the sun. However, should the Saturn V Workshop be oriented broadside to the sun the Saturn I thermal control system concept is adequate.

In conjunction with other Saturn V Orbital Workshop studies, a review was conducted of MSFC's preliminary attitude control analyses. (84) It was found that attitude control of the Saturn V Orbital Workshop with its roll axis aligned with the solar vector results in larger fuel requirements for momentum management, the need for additional control moment gyros, and more frequent momentum desaturation operations. MSFC's conclusion that broadside orientation is preferable from the control standpoint was endorsed.

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(81) Subsystem Modifications to Develop Quiescent Operation for Gemini B, Memorandum for File, R. K. McFarland, February 28, 1968.

(82) A Review of Water Reclamation Systems for AAP, Memorandum for File, J. J. Sakolosky, February 1, 1968.

(83) Thermal Implications of "End-Pointing" vs. "Side-Pointing" for Workshop B, Memorandum for File, D. J. Belz, March 15, 1968.

(84) Side Pointing vs. End Pointing for Workshop B, Memorandum for File, J. Kranton, March 15, 1968.

## MISSION OPERATIONS STUDIES

The final report by BTL on the analysis of the load carrying capability of Communications, Command and Telemetry System (CCATS) at the Mission Control Center-Houston (MCC-H) was distributed.<sup>(85)</sup> The report describes the concept and status of the effort at the end of 1967 when the task was terminated.

The performance of the Operational Intercommunications System (OIS) was monitored during the Apollo 5 prelaunch tests and launch. The observations made were reported to KSC for use in the overall evaluation of the system.<sup>(86)</sup>

The status of the modification of the OIS (Audio) at Launch Complex 34 from a 2-wire to a 4-wire configuration was reviewed by representatives of Bellcomm and BTL. The 4-wire modification is in accordance with a method suggested by BTL during the analysis of OIS(Audio) problems last year. A demonstration of part of the converted OIS indicated that it was performing in accordance with the design intent.

The functions of the Manned Space Flight Network (MSFN) station at Canary Island (CYI) for Apollo and AAP missions were reexamined.<sup>(87)</sup> It was concluded that the role of CYI in an Apollo lunar mission is diminished by removal of the requirement for lunar injection during the last half of the first orbit. However, CYI does contribute significantly to coverage during long duration Apollo test missions and AAP missions.

The roles of ground-based flight control and experience during previous manned space flight missions were examined. A number of functions that are uniquely appropriate to ground-based flight control during nominal missions were identified. In addition, ground-based flight control enables successful

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(85) Communications Processor - Loading Studies - Time Usage Model - The Simulation Concept, Memorandum for File, C. W. Schramm, Bell Telephone Laboratories, December 6, 1967.

(86) Performance of Operational Intercommunication System-Audio (OIS-A) During Apollo 5, Memorandum For File, J. E. Johnson, H. Kraus, J. P. Maloy, B. F. O'Brien, January 29, 1968.

(87) Review of Role of MSFN Station at Grand Canary Island in Apollo and AAP, Memorandum for File, J. P. Maloy, March 8, 1968.

handling of off-nominal situations. An oral report on the results of the examination was made to the Director of Mission Operations.

An overall review of the up-data system for Apollo missions was initiated to determine whether data will be transmitted in an accurate and timely manner in accordance with requirements for the lunar landing mission.

A brief review of the use of lasers in space communications was completed. (88) It was noted that lasers have been used primarily for tracking and very little for communications.

An analysis was completed of a proposed digital detection scheme for coded phase-coherent communications. (89) The system digitizes the integrated received waveform and allows the correlation process to be performed in a digital computer. It provides near optimum performance.

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(88) Laser Applications in NASA Space Programs, Memorandum for File, R. K. Chen, March 4, 1968.

(89) Analogue to Digital Conversion Requirements in Partial Digital Detection of Coded Phase Coherent Transmissions, TM-68-2034-3, L. Schuchman, March 15, 1968.

SPECIAL TASK ENGINEERING STUDIES

ASSISTANCE IN CERTAIN COMPUTER OPERATIONS AND  
RELATED ACTIVITIES

TASK ORDER NO. 12

During the report period from January 1 through March 31, NASA usage of the UNIVAC 1108 computer was 57.63 hours. There was no independent usage (non-NASA) of the 1108 computer during this time.

## MANNED SPACE FLIGHT EXPERIMENTS PROGRAM STUDIES

### TASK ORDER 27

In this quarter, the final report on Task 27 was issued and the Task Order was formally completed. (90) Work in this area is continuing as part of ADVANCED MANNED MISSIONS SYSTEMS ENGINEERING.

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(90) Final Report - Task 27 - Manned Space Flight Experiments Program,  
TR-68-227-1, F. G. Allen, G. T. Orrok, March 29, 1968.

## GENERAL MISSION ENGINEERING STUDIES

### Mission Control Center Performance

The study of augmentation requirements for the Real Time Computer Complex (RTCC) and the Simulation, Checkout and Training System (SCATS) in the Mission Control Center, first investigated during the GOSS Augmentation Study, was completed. (91)

It was concluded that with certain changes in flight control philosophy, the presently used stand-alone concept—one 360/75 with a second as backup providing real time support for a mission—could support the missions analyzed in the study. Also, with minor compromises one 360/75 could simulate, for training purposes, the data outputs of any of these missions.

Based on these conclusions, estimates were made for the number of computers required to support a range of schedule densities. It was determined that the present RTCC-SCATS computer complement is adequate for an Apollo schedule with three-month launches interleaved with a "light" AAP schedule.

### ADP Master Plan

The study of Automatic Data Processing (ADP) master planning for the Office of Manned Space Flight continued. The planning and control system in use at the Jet Propulsion Laboratory was studied to determine if any of its features were relevant to MSF. (92)

### Computer System Operability and Repairability

The state of a redundant system of  $N$  identical computers with repair crews is given by the number of computers actually working at a given time. Mathematically, the system can be represented as a birth-death process with given failure rate and repair time. This leads to a system of  $N+1$  differential equations whose solution gives the probability of being in each state.

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(91) Augmentation Requirements for Mission Control and Training Computers in the MCC-H, Memorandum for File, J. R. Birkemeier, B. H. Liebowitz, February 23, 1968.

(92) An Example of Planning for and Control of ADP Resources, Memorandum for File, L. B. Nothorn, March 29, 1968.

An analytic solution to these transition probabilities of the process, given that all computers were initially working, has been calculated together with its asymptotic distribution. (93) The transition probabilities were used to derive a formula for the Laplace transform of the distribution of the first time to system failure.

By another method, the differential equations were solved directly for arbitrary initial system state. (94) This allows the determination of the time to reach an asymptotic steady state and points out the importance of the mean time to repair being much smaller than the mean time to failure.

#### Orbiter State Vector Determination

A technique for determining the state vector of a planetary orbiter using earth-based range-rate measurements is being studied. (95) In the analysis, four methods of solution of a system of non-linear equations, including a new generalized differential correction method, are compared. Initial results indicate that the new method has the widest range of convergence of the initial state vector estimate. This extension of convergence range increases the probability of obtaining a preliminary state vector in a short tracking interval, a capability which is particularly important in planetary missions.

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(93) A Birth-Death Process Associated with a Redundant Repairable System, TM-68-1033-1, G. R. Andersen, March 4, 1968.

(94) On Finding the Eigenvalues and Eigenvectors of a Tridiagonal Matrix Arising in a Reliability Study, TM-68-1033-2, L. C. Nelson, March 13, 1968.

(95) Approximate Solutions of M Nonlinear Equations in N Unknowns for  $M \geq N$ , Abstract of paper to be presented at the June 1968 meeting of the Society for Industrial and Applied Mathematics, C. L. Greer, March 26, 1968.

## ENGINEERING SUPPORT

### Computing Facility

The UNIVAC 1108 Computer operations continued under the EXEC II batch processing operating system. Several modifications were made to the system software during the period to improve efficiency and reliability. Hardware and software changes were made to provide remote 1004 Print/Read and Punch operations at FOB-10 and acceptance of the 1004 equipment was successfully accomplished.

EXEC 8 is the advanced executive system being developed by UNIVAC that will provide the multi-programming and multiple terminal access features needed by Bellcomm. Some system testing under current versions of EXEC 8 is underway although this executive system does not yet meet the contractual requirements. UNIVAC efforts on EXEC 8 are continuing.

Programming support for the various Bellcomm engineering and scientific studies was continued during the report period.

## ADMINISTRATIVE

### Personnel

Effective March 15, 1968 I. M. Ross was elected President of Bellcomm replacing W. C. Hittinger.

## LIST OF REPORTS AND MEMORANDA

(Listed in Order of Report Date)

This index includes technical reports and memoranda reported during this period covering particular technical studies.

The memoranda were intended for internal use. Thus, they do not necessarily represent the considered judgment of Bellcomm which is reflected in the published Bellcomm Technical Reports.

TITLE	DATE
<u>Reduction of Look Angle Sensitivity to Altitude Updates During LM Descent Visibility Phase, Memorandum for File, G. N. Klemuschin, R. W. Srch, Bell Telephone Laboratories</u>	November 13, 1967
<u>Communications Processor - Loading Studies - Time Usage Model - The Simulation Concept, Memorandum for File, C. W. Schramm, Bell Telephone Laboratories</u>	December 6, 1967
<u>Operational Intercommunication System Monitoring During Apollo 5 FRT, Memorandum for File, B. F. O'Brien</u>	January 3, 1968
<u>Comments on Experiment Implementation Plan for Experiment M479, Zero Gravity Flammability, Memorandum for File, M. S. Feldman</u>	January 3, 1968
<u>Passive Stability of the Local Vertical (Gravity-Gradient) Orientation of the Orbital Workshop (OWS), TM-68-1022-1, J. Kranton</u>	January 5, 1968
<u>A Lunar Exploration Program, TM-68-1012-1, N. W. Hinners, D. B. James, F. N. Schmidt</u>	January 5, 1968
<u>Countdown Hold Statistics, TM-68-2014-1, W. B. Gevarter</u>	January 8, 1968
<u>Weight Estimates of Ellipsoidal and Elliptical-Toroidal Bulkheads of a Common Mission Module, Memorandum for File, C. E. Johnson, C. C. Ong</u>	January 9, 1968

TITLE	DATE
<u>Comments on Experiment Implementation Plan for Experiment M489, Wicking Evaporative Heat Sinks, Memorandum for File, M. S. Feldman</u>	January 9, 1968
<u>A Compendium of the Moon's Motion and Geometry: 1966 through 1985, TR-68-310-1, J. O. Capellari, Jr.</u>	January 9, 1968
<u>Comments on Design Policy for the Use of Radiators in a Meteoroid/Asteroid Environment for Advanced Manned Missions, Memorandum for File, C. E. Johnson</u>	January 10, 1968
<u>Appraisal of Unmanned Planetary Program Alternatives to Voyager in the Period 1968-1975, Memorandum for File, P. L. Chandeysson, M. Cutler</u>	January 16, 1968
<u>Review of Experiment T-013, Crew/Vehicle Disturbance, Memorandum for File, J. Kranton, C.A. Pearse, S. L. Penn</u>	January 16, 1968
<u>An Alternate Apollo Applications Program for Earth Orbit, Memorandum for File, G.M. Anderson, W.W. Hough, J. Kranton, R.K. McFarland, B.W. Moss, J.J. Sakolosky, D.P. Woodard</u>	January 17, 1968
<u>Astronaut Visibility of Features from the Lunar Surface, Memorandum for File, A. F. H. Goetz</u>	January 19, 1968
<u>Final Report - Task 28 "Data Processing for Advanced Manned Missions", TR-68-228-1, P. S. Schaenman</u>	January 22, 1968
<u>The Boyd-Boksenberg Image Storage System, Memorandum for File, T. C. Tweedie, Jr.</u>	January 22, 1968
<u>Use of a Battery from the Extended LM to Power a Lunar Roving Vehicle, Memorandum for File, J. Gillespie</u>	January 25, 1968 Ernst M. Cohn
<u>Comments on the Instrumentation and Communication System of the ATM as Proposed by MSFC at the ATM PRR, Memorandum for File, A. G. Weygand</u>	January 25, 1968
<u>Performance of Operational Intercommunication System-Audio (OIS-A) During Apollo 5, Memorandum for File, J. E. Johnson, H. Kraus, J. P. Maloy, B. F. O'Brien</u>	January 29, 1968

TITLE	DATE
<u>Number Density of Martian Craters,</u> TR-68-710-1, A. H. Marcus	January 29, 1968
<u>A Proposed Plan for Geologic Exploration on the</u> <u>Second Apollo Landing Mission, Memorandum for</u> File, A. F. H. Goetz	January, 31, 1968
<u>Analysis on the Operation of the Fine Tone Tracking</u> <u>Loop of the LM VHF Ranging Transponder,</u> TM-68-2034-2, K. H. Schmid	February 1, 1968
<u>A Review of Water Reclamation Systems for AAP,</u> Memorandum for File, J. J. Sakolosky	February 1, 1968
<u>Status of Apollo Abort Advisory System (AAS) for</u> <u>AS-502, Memorandum for File, C. H. Eley III</u>	February 1, 1968
<u>The Pointing Accuracy Attainable with Orbiting</u> <u>Gimbal-Mounted Telescopes, Memorandum for</u> File, P. G. Smith	February 2, 1968
<u>Status of McDonnell-Douglas Thermal Analyses</u> <u>of the Orbital Workshop, Memorandum for File,</u> D. J. Belz	February 5, 1968
<u>Triplicated Interface Element for Triply Redundant</u> <u>Modules in Digital Devices, Memorandum for File,</u> D. O. Baechler	February 5, 1968
<u>Contributions of the Apollo Materials Selection and</u> <u>Test Program to Future Manned Systems,</u> Memorandum for File, S. S. Fineblum	February 6, 1968
<u>On-Pad Command Module Leak Check for Block II</u> <u>Spacecraft, Memorandum for File, L. G. Miller</u>	February 6, 1968
<u>Halon 1301 Toxicity: A Status Report, Memorandum</u> <u>for File, L. G. Miller</u>	February 7, 1968
<u>Optical Astronomy on a Manned Planetary Flyby</u> <u>Mission, Memorandum for File, W. D. Grobman</u>	February 8, 1968

TITLE	DATE
<u>The Relation of In-flight Loads to the S-II Cryogenic Proof Test, Memorandum for File, R. E. Hunter</u>	February 9, 1968
<u>Three Experiments for the En Route Phase of a Planetary Flyby Mission, Memorandum for File, W. D. Grobman</u>	February 9, 1968
<u>Coupled vs. Decoupled LM/ATM Mission Concepts: System Configuration Aspects, Memorandum for File, R. K. McFarland</u>	February 14, 1968
<u>A Lunar Landing Mission to a Mare Ridge, Memorandum for File, M. T. Yates</u>	February 14, 1968
<u>Analytical Solution to an Optimum Two Burn Deboost Into Parking Orbit, Memorandum for File, S. F. Caldwell</u>	February 14, 1968
<u>Effect of Earth Occultation on Astronomical Observations from Earth Orbit, Memorandum for File, D. B. Wood</u>	February 15, 1968
<u>Communication System Design for an MM-Drag Probe Link on Manned Mars Flyby Missions, TM-68-2034-1, R. K. Chen</u>	February 15, 1968
<u>LM/ATM Unmanned Rendezvous and Docking, Memorandum for File, K. E. Martersteck</u>	February 15, 1968
<u>Review of AAP I/C Panel Instrumentation and Communications Interface Control Documents, Memorandum for File, A. G. Weygand</u>	February 15, 1968
<u>ALSEP Central Station Thermal Design, Memorandum for File, P. J. Hickson</u>	February 16, 1968
<u>Recent Activities Relating to the Use of Halon 1301 at KSC, Memorandum for File, L. G. Miller</u>	February 19, 1968
<u>Earth Resources Aircraft Program Test Site Coverage by Expected AS-502 Color Photography, Memorandum for File, B. E. Sabels</u>	February 19, 1968

TITLE	DATE
<u>A Semi-automatic Procedure for Controlling CM Cabin Atmosphere Enrichment, Memorandum for File, R. D. Raymond</u>	February 21, 1968
<u>Experiment Payloads for Manned Encounter Missions to Mars and Venus, TR-68-710-2, W. B. Thompson, J. E. Volonte, G. A. Briggs, P. L. Chaneysson, M. Cutler, E. M. Grenning, W. D. Grobman, R. N. Kostoff</u>	February 21, 1968
<u>A Venus Lander Probe for Manned Flyby Missions, TR-68-710-3, P. L. Chaneysson</u>	February 23, 1968
<u>Augmentation Requirements for Mission Control and Training Computers in the MCC-H, Memorandum for File, J. R. Birkemeier, B. H. Liebowitz</u>	February 23, 1968
<u>Lightning Discharges and Sferics, Memorandum for File, W. R. Sill</u>	February 23, 1968
<u>Examination of the Efficiencies Possible in the AAP Medical Experiment Program, TM-68-1011-1, R. E. McGaughy</u>	February 23, 1968
<u>A Feasible Planetary Exploration Program Through 1980, TM-68-1014-1, J. P. Downs, W. B. Thompson</u>	February 26, 1968
<u>Crew/Suit Configurations with a 60:40 O<sub>2</sub>:N<sub>2</sub> CM Cabin Atmosphere, Memorandum for File, T. A. Bottomley, Jr.</u>	February 26, 1968
<u>Launch Azimuth from the Pacific Missile Range, Memorandum for File, J. J. Schoch</u>	February 28, 1968
<u>Subsystem Modification to Develop Quiescent Operation for Gemini B, Memorandum for File, R. K. McFarland</u>	February 28, 1968
<u>Control of Cabin Atmospheric Contamination in the AAP Cluster, Memorandum for File, D. J. Belz</u>	February 28, 1968

TITLE	DATE	
<u>Possible Approach to Phasing for Unmanned Rendezvous</u> , Memorandum for File, K. E. Martersteck	February 29, 1968	
<u>Flight Planning Study - Review of Gemini Flight Plans</u> , Memorandum for File, B. H. Crane	March 1, 1968	
<u>Laser Applications In NASA Space Programs</u> , Memorandum for File, R. K. Chen	March 4, 1968	
<u>A Birth-Death Process Associated With A Redundant Repairable System</u> , TM-68-1033-1, G. R. Andersen	March 4, 1968	
<u>AAP 3-4 Electrical Energy Sources and Load Requirements</u> , Memorandum for File, B. W. Moss	March 4, 1968	Ernst M. Cohn
<u>CM Cabin Atmosphere Briefing</u> , Memorandum for File, T. L. Powers	March 5, 1968	
<u>CSM Configurations to Support Saturn V Workshops</u> , Memorandum for File, J. J. Gabrik, W. W. Hough	March 5, 1968	
<u>Semi-Analytic Solution to an Optimum, Two-Impulse Targeting Problem</u> , TM-68-2011-1, S. L. Levie, Jr.	March 7, 1968	
<u>On the Interaction of the Solar Wind with Planetary Bodies</u> , TM-68-1014-2, J. L. Blank	March 7, 1968	
<u>Review of Role of MSFN Station at Grand Canary Island in Apollo and AAP</u> , Memorandum for File, J. P. Maloy	March 8, 1968	
<u>AAP-1/AAP-2 Simplified Mission Description</u> , Memorandum for File, D. S. Lopez	March 11, 1968	
<u>Orbital Workshop Environmental Control System</u> , Memorandum for File, D. J. Belz	March 11, 1968	
<u>Simplified Software for the Apollo Guidance Computer - CSM Powered Flight Programs</u> , Memorandum for File, D. A. Corey	March 11, 1968	
<u>On Finding the Eigenvalues and Eigenvectors of a Tridiagonal Matrix Arising in a Reliability Study</u> , TM-68-1033-2, L. D. Nelson	March 13, 1968	

TITLE	DATE
<u>CSM Electrical Source/Distribution Bus Configurations During Manned Block II Flight, Memorandum for File, W. H. Hodge</u>	March 14, 1968 Ernst M. Cohn
<u>Side Pointing vs. End Pointing for Workshop B, Memorandum for File, J. Kranton</u>	March 15, 1968
<u>Analogue to Digital Conversion Requirements in Partial Digital Detection of Coded Phase Coherent Transmissions, TM-68-2034-3, L. Schuchman</u>	March 15, 1968
<u>Thermal Implications of "End-Pointing" vs. "Side-Pointing" For Workshop B, Memorandum for File, D. J. Belz</u>	March 15, 1968
<u>Lunar Flying Unit Trajectory and Sortie Analysis, TM-68-1022-2, J. W. Powers</u>	March 15, 1968
<u>Radioisotopic Heat Sources for Space Power Application, Memorandum for File, C. P. Witze</u>	March 15, 1968
<u>Trapped Radiation Doses, Memorandum for File, R. H. Hilberg</u>	March 15, 1968
<u>Supercritical Cryogenics Management Between MSS Removal and Launch - Apollo 6, Memorandum for File, G. W. Craft</u>	March 19, 1968
<u>Compatibility of Experiment S051, Sodium Cloud Photography, with Early AAP Missions, Memorandum for File, T. C. Tweedie, Jr.</u>	March 21, 1968
<u>AAP-2 Conditions Prior to Launch of AAP-1, Memorandum for File, A. W. Starkey</u>	March 21, 1968
<u>Analysis of S-II Fracture Mechanics Data, Memorandum for File, R. E. Hunter</u>	March 22, 1968
<u>Feasibility of A Simplified LM Ascent and Rendezvous Scheme, Memorandum for File, D. R. Anselmo, D. J. Toms</u>	March 26, 1968

TITLE	DATE
<u>An Open Loop Crew-Monitored LM Descent,</u> Memorandum for File, F. Heap	March 26, 1968
<u>Approximate Solutions of M Nonlinear Equations</u> <u>in N Unknowns for <math>M \geq N</math>, Abstract of paper to be</u> presented at the June 1968 meeting of the Society for Industrial and Applied Mathematics, C. L. Greer	March 26, 1968
<u>A Survey of Possible Experiments for a Mars</u> <u>Entry Probe: I, Mass Spectrometer, Memorandum</u> for File, C. P. Wang	March 26, 1968
<u>LM Descent Guidance for a Feasibility Study to</u> <u>Simplify Apollo Guidance, Memorandum for File,</u> G. L. Bush	March 27, 1968
<u>Proposed Simplification of the CSM-Digital Autopilots,</u> Memorandum for File, A. Heiber, F. La Piana	March 27, 1968
<u>A LM Rescue Strategy Requiring No On-Board</u> <u>Targeting, Memorandum for File, S. L. Levie, Jr.</u>	March 28, 1968
<u>AS-502 Entry Accuracy, TM-68-2014-2, I. Bogner,</u> S. B. Watson	March 28, 1968
<u>Review of the Second Arizona Conference on</u> <u>Planetary Atmospheres, Tucson, Arizona,</u> <u>March 11-13, 1968, Memorandum for File,</u> M. Liwshitz	March 28, 1968
<u>Relative Effectiveness of Several Materials as</u> <u>Radiation Shields, Memorandum for File,</u> R. H. Hilberg	March 29, 1968
<u>Apollo CSM Photographic Planning, Memorandum</u> for File, W. L. Piotrowski	March 29, 1968
<u>A Proposal for Uprating the LM Supercritical</u> <u>Helium (SHe) System, Memorandum for File,</u> D. M. Duty	March 29, 1968
<u>An Example of Planning for and Control of ADP</u> <u>Resources, Memorandum for File, L. B. Nothern</u>	March 29, 1968

TITLE	DATE
<u>Modifications to the BCMASP Simulator for Saturn IB Trajectories</u> , Memorandum for File, I. Hirsch	March 29, 1968
<u>Feasibility Study for Simplified Apollo Guidance</u> , Memorandum for File, R. V. Sperry	March 29, 1968
<u>Final Report - Task 27 - Manned Space Flight Experiments Program</u> , TR-68-227-1, F. G. Allen, G. T. Orrok	March 29, 1968
<u>AGC Reprogramming Study - Utility and Service Programs</u> , Memorandum for File, J. J. Rocchio	March 29, 1968